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GUIDELINES FOR SUBSTATION SERVICE INSPECTION & CONDITION MONITORING



**PSS T & D SUBSTATION – QUALITY MANAGEMENT
ABB LTD.**

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1) INTRODUCTION

This guideline is prepared in view of the requirements for switchyard service inspection (visual) and condition based maintenance of substation equipments, structures and other miscellaneous items in substations. These guidelines are necessarily general. It is recommended to carry out maintenance of equipment as per manual supplied by manufacturer. All inspections and test procedures should also be performed in accordance with applicable codes and standards.

The aim of this guideline is to provide in general visual inspection check points for the structures, grounding systems, LT switchboards, etc. for which as such there is no readymade guidelines available. Also to provide the visual inspection and condition based maintenance of Major equipments like Transformer, Circuit breakers, CTs, CVTs, PTs, Disconnectors and LAs etc. to verify the health of the equipments.

Service visual inspection is the necessary activity to identify any visible abnormality or failure and require to be performed at specified interval. Whereas condition based monitoring checks (on line/ off line) are necessary to identify internal defects or abnormality, so that necessary preventive action can be taken up.

2) SERVICE INSPECTION & CONDITION MONITORING GUIDELINE

The substation in total and the individual items of equipment contained therein should be periodically inspected. Binoculars should be used to view buses and other equipment located on structures.

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Painting and Galvanizing (Applicable to all equipments and systems)

Depending on geographical location, local environmental condition, periodic inspection of painting and galvanizing condition of structures, panels, equipments etc. is required. Inspect for paint condition, damage paint, chalking effect, rusting etc. If any damage observed, do necessary repaint or repair work.

Grounding System

Check for loose connections of all ground connections at equipments, structures, panels, other equipments etc. Check for any sparking marks at termination or joint. Observe the condition of any flexible braid type connections for damage. Tighten the connections, clean the joints and replaced if found damage. Earth pits should be kept wet so as to have low resistance. Measure overall ground grid resistance. The Value obtained should be comparable with initially measured values or designed values.

Structure

Inspect all the structures for loose or missing bolts or nuts. Observe any damage paint/ galvanizing or signs of corrosion. Inspect for deterioration, bending, buckling and cracking.

Civil work-Foundation and Control Room

Inspect for sings of settlement, cracks, spalling, honeycombing, exposed reinforcing steel, and anchor bolt corrosion. Check for break/ missed cable trench cover. Inspect for any crack/ leakages in control room and water tank. Check for proper functioning of sump pump and drainage system.

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Buses and Shield wire

Inspect for loose clamps or connections. Inspect for bending of Alu-tube bending. Observe the condition of flexible buses and shield wires for any damages.

Porcelain Insulators and Bushings (For Bus post / Suspension / Circuit breaker / CT / CVT / PT & Transformer bushings)

Inspect all insulators and equipment bushings for chipped petticoats and fractured or cracked porcelain. Flashover in the past may have damaged a portion of the glazing on the porcelain. Make this inspection at close range. Replaced damage bushings. Remove dust and dirt from porcelain insulators with suitable methods.

Cable

Inspect exposed sections of cable for physical damage. Inspect the insulation or jacket for signs of deterioration. Check for loose connections, lugs, tightness, cracking of lugs etc. Inspect shield grounding (where applicable), cable support and termination. Check for any sparking marks at termination or joint. Clean sparking marks if any and make proper joint with proper tightening and lugging.

LT Cable & Metal clad switchgear (Control-Metering, Relay panel, Outdoor and indoor panel)

Examine meters, relays and instruments externally to check for loose connections and damage to cases and covers. Check whether the instruments are reading or registering. Check the functioning of annunciator panels. Inspect for damage to enclosures, doors, latching mechanisms, locks etc. Check out for burned-out lamps.

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Battery and battery charger

Batteries:

Check for any physical damage, loose connections. Check for low level or low specific gravity of the electrolyte. Record the electrolyte temperature. Verify vent cap and flame arresters are in place. Check electrolyte appearance. Check working of exhaust fan.

Racks:

Check for cleaning and corrosion.

Battery charger:

Observe temperature (by touch). If temperature is found high, check and attend the reason for the same. Check the charging current and voltage. Observe the ground detector lamps for an indication of an undesirable ground on the dc system.

Compressor

Check for leakage of air. Check air pressure and Oil level.


Substation area- General

- Verify the existence of appropriate danger and informational warning signs. Verify whether they are missing or needs repainting.
- Check for rusting of fasteners
- Check for any hotspots at conductor/ equipment/ stringing termination.
- Check for indoor and outdoor lighting systems for burned-out lamps or other component failures
- Verify that there is adequate supply of spares
- Inspect the fire protection system

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- Check for bird/ animal nests or other foreign materials in the vicinity of energized equipment, buses or fans.
- Observe the general condition of the substation yard, overall cleanliness
- Observe the position of all circuit breakers in the auxiliary power system and verify the correctness of this position (indication on breaker).
- Inspect the area for weed growth, trash and unauthorized equipment storage.
- Ensure the fence fabric is intact and there is no rust.
- Ensure the gate latches are operable
- Ensure flexible braid-type connections are intact.

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1. TRANSFORMER

A) Service Inspection Schedule

Sr.No.	Details	Frequency
1	Checking of oil leaks	M
2	Checking of oil level in main tank	M
3	Checking of bushing oil level	M
4	Checking of oil level in conservator	M
5	Checking of oil level in OLTC conservator	M
6	Checking of oil level in oil seal of breather	M
7	Checking of condition of silica gel in breather	M

B) Maintenance Schedule

Sr.No.	Details	Frequency
1	Check manual/ auto actuation of cooler oil pumps and fans	Y
2	Cleaning of all bushings	Y
3	Replacement of damage/ cracked bushings	SOS
4	Tightening of loose terminals	SOS
5	Maintenance of OLTC driving mechanism	Y
6	Checking and cleaning of diverter contacts	2Y
7	Checking and calibration of OTI , WTI	2Y
8	Checking of all remote indications (WTI and Tap position indicator) and top up oil in pockets, if required	Y
9	Electrical checking/ testing of pressure relief device, Buchholz relay, OLTC surge relay/ checking of alarm/ trip contacts	Y
10	Checking/ replacements of gaskets of terminal box	Y
11	Checking/ testing of Buchholz relay by oil draining	Y
12	Filtration/ degassing of main tank oil	SOS
13	Filtration/ replacement of oil of OLTC	SOS
14	Testing of bushing CTs Testing of bushing CTs	SOS
15	Checking tightness of earthing connections	Y
16	Checking of alignment of horn gap	Y
17	Check for damage paint condition and corrosion for complete transformer with control cabinet	Y

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18	Marshalling box	
*	(i) Cleaning of marshalling boxes of transformer and OLTC	Y
*	(ii) Tightening of terminations	Y
*	(iii) Checking of contactors, space heaters, illumination etc.	Y
19	External cleaning of radiators	Y
20	Check tightness of all clamps and connectors	Y


C) Condition Monitoring (Condition based Maintenance)

Sr.No.	Details	Frequency
1	Dissolved Gas Analysis	½ Y
2	Oil physical and chemical tests	½ Y
3	Infrared scan	2Y
4	Ultrasonic Partial discharge	2Y
5	Sonic Fault detection	2Y
6	Vibration Analysis	2Y
7	BDV, ppm of OLTC Diverter compartment oil (less frequently if operations are not more)	Y
8	Frequency Response Analysis	SOS
9	C & Tan δ measurement of bushings	Y
10	C & Tan δ measurement of windings	2Y
11	IR measurement of windings (Polarization index and D.A. Ratio)	2Y
12	Measurement of winding resistance at all tap positions	4Y
13	Measurement of winding ratio	SOS
14	Recovery voltage measurement	SOS
15	Degree of polymerization	SOS
16	Core to Ground resistance	SOS
17	Magnetic Balance test	SOS
18	Magnetizing current test	SOS
19	Furfuradehyde analysis	SOS

2. CIRCUIT BREAKERS (SF6 & AIR BLAST)

A) Service Inspection Schedule


Sr.No.	Details	Frequency
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1	Check for any gas/ air leakage	M
2	Check for proper gas/ air pressure	M
3	Check for any hot spots at any terminals	M
4	Checking of oil leaks from grading capacitors	M
5	Checking of air compressor for oil level, oil quality, air filter, V-belt tension	QY
6	Check for crack in insulators	M

B) Maintenance Schedule

Sr.No.	Details	Frequency
1	Check tightness of all clamps and connectors / terminals	Y
2	Check for damage paint condition and corrosion	Y
3	Replaced damaged bushings	SOS
4	Checking of all interlocks	Y
5	Checking of pressure settings	Y
6	Cleaning of breaker interrupter, support insulators, PIRs and grading capacitors	Y
7	Checking of Close/ trip coil currents	Y
8	Checking of healthiness of operation counter	Y
9	Control cabinet	
	(i) Checking of tightness of all cable termination in MB	Y
	(ii) Checking of door sealing gaskets and replacement, if necessary	Y
	(iii) Repainting of metallic surfaces	SOS
	(iv) Checking of space heaters	Y
10	Checking of tightness of foundation bolts	Y
11	Maintenance of air dryers in Air blast circuit breakers	½ Y
12	Functional checking of auto starting of air compressors and dryers	Y
13	Checking of air pressure drop during duty cycle operation	Y
14	Overhauling of compressors	SOS
15	Maintenance of air dryer if provided	½ Y

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16	Spring operated mechanism	
	(i) Oil leakages from close and open dashpots, replace the same if leakage observed	Y
	(ii) Greasing/ lubrication of gears and various latches in the operating mechanism	Y
	(iii) Checking of play of gaps in catch gears	Y
	(iv) Maintenance of spring charging motors, cleaning of carbon brushes and contactors	Y
	(v) Replacement of oil in dashpots	SOS
17	Checking of pole discrepancy relay	Y
18	Functional checks, duty cycle operation including rapid re-closing (O-0.3s-CO)	Y
19	Checking of air pressure drop during duty cycle operation	U
20	Checking of all operational lock-outs including SF6 density monitor	Y
21	Checking tightness of earthing connections	Y
22	Cleaning of auxiliary switch contacts with CTC	Y
23	Checking of local ON/OFF indicating lamps in breaker, if provided	Y
24	Check interlocking of isolators with breaker	Y
25	After maintenance trip the breaker through backup	Y

C) Condition Monitoring (Condition based Maintenance)

Sr.No.	Details	Frequency
1	CB operating timings (Main, PIR, Aux.)	Y
2	Static contact resistance measurement	2Y
3	Dynamic contact resistance measurement (DCRM), contact travel, contact speed, contact wipe, arcing contact length	2Y
4	Capacitance and tan δ measurement of grading capacitors	4Y
5	Dew point measurement of SF6 gas	3Y

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6	Dew point measurement of operating air at the outlet of air dryer (for Air blast CB)	Y
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3. CURRENT TRANSFORMER

A) Service Inspection Schedule


Sr.No.	Details	Frequency
1	Checking of bellow expansion	M
2	Checking of oil leakage and crack in insulators etc.	M
3	CT Marshalling box	
	- Checking of oil leakage in terminal box	M
4	Check corona effects	M

B) Maintenance Schedule

Sr.No.	Details	Frequency
1	Checking of oil leakage in terminal box	Y
2	Checking of primary connection strips, if provided externally	Y
3	N2 pressure checking	2Y
4	Checking of primary connection strips, if provided internally	SOS
5	Checking of burden on secondary winding	SOS
6	CT Marshalling box	
	- Check healthiness of gaskets	Y
	- Checking of space heater and illumination	Y
	- Checking the tightness of all connections including earthing of PF terminal	Y
	- Cleaning of marshalling box and junction box	Y
7	Checking for rusting and paints	Y
8	Check tightness of all clamps and connectors / terminals	Y
9	Checking tightness of earthing connections	Y

C) Condition Monitoring (Condition based Maintenance)

Sr.No.	Details	Frequency
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1	Thermovision scanning of CT	Y
2	Measurement of Capacitance and Tan δ	2Y*
3	IR measurement (DAR)	2Y
4	Measurement of CT secondary resistance	SOS
5	Magnetization characteristics	SOS
6	CT ratio test	SOS
7	DGA and testing of other parameters of oil	SOS

* To be repeated before one year from commissioning and then as per schedule

4. POTENTIAL TRANSFORMERS/ CAPACITANCE VOLTAGE TRANSFORMERS/ COUPLING CAPACITORS

A) Service Inspection Schedule

Sr.No.	Details	Frequency
1	Checking of bellow expansion	M
2	Checking of oil leakage and crack in insulators etc.	M
3	Marshalling box	
	- Checking of oil leakage in terminal box	M
4	Check corona effects	M

B) Maintenance Schedule

Sr.No.	Details	Frequency
1	Checking of oil leakage in terminal box	Y
2	Measurement of voltage at control room panel	1/2 Y
3	Visual checking of earthing HF point (in case it is not being used for PLCC)	Y
4	Checking of any breakage or cracks in cementing joint	Y
5	Cleaning of CVT capacitor stacks and tightness of terminal connections	Y

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6	Marshalling box	
	- Check healthiness of gaskets	Y
	- Checking of space heater and illumination	Y
	- Checking the tightness of all connections including earth connections	Y
	- Cleaning of marshalling box and junction box	Y
7	Checking for rusting and painting	Y
8	Check tightness of all clamps and connectors / terminals	Y
9	Checking tightness of earthing connections	Y

C) Condition Monitoring (Condition based Maintenance)

Sr.No.	Details	Frequency
1	Thermovision scanning of Capacitor stacks	Y
2	Measurement of Capacitance and Tan δ	3Y*
3	Testing of EMU tank oil for BDV (if oil found discolored)	SOS

* To be repeated before one year from commissioning and then as per schedule. This test is not possible to be conducted at site if isolation of neutral of intermediate PT is not possible at site.

5. DISCONNECTORS AND EARTH SWITCHES

A) Service Inspection Schedule

Sr.No.	Details	Frequency
1	Checking of cracks in insulators	Y
2	Observe the condition of contact surfaces and the area around them	QY
3	Inspect the ease of operating mechanism (if possible)	QY

B) Maintenance Schedule

Sr.No.	Details	Frequency
1	Cleaning and lubrication of main contacts, earthing blades, pins and bearings	Y
2	Checking of tightness of bolts, nuts and pins, etc.	Y
3	Cleaning of support insulators and checking of	Y

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	insulator cracks, if any	
4	Checking of interlocks	Y
5	Checking of earth connections of structure, MOM box and earth switch	Y
6	Operation check of isolator and earth switch	Y
7	Checking of alignments of main contacts and earthing blades	2Y
8	Checking and lubrication of linkages including transmission gears	Y
9	Checking and tightening of stopper bolts	Y
10	Cleaning of auxiliary switch contacts and greasing with silicon grease	Y
11	Lubrication of operating mechanism hinges, lock joints on levers, bearings	Y
12	Checking of all mounting bolts for tightness	Y
13	Checking of healthiness of door gaskets	Y
14	Checking of tightness of electrical connections	Y
15	Checking of spare heaters and illumination	Y
16	Checking of aluminum/ copper flexible connectors	Y
17	Checking for rusting and paints	Y
18	Check corona balls and rings for damage	Y

C) Condition Monitoring (Condition based Maintenance)

Sr.No.	Details	Frequency
1	Thermovision scanning	Y
2	Main contact resistance measurement	2Y
3	Earthing contact resistance measurement	2Y

6. SURGE ARRESTERS

A) Service Inspection Schedule

Sr.No.	Details	Frequency
1	Checking of cracks in insulators	QY
2	Check for pitted or blackened exhaust parts or other	QY

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	evidence of pressure relief	
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B) Maintenance Schedule

Sr.No.	Details	Frequency
1	Testing of counters and leakage current meters	Y
2	Cleaning of insulators	Y
3	Checking of earth connections between surge arrester, surge monitor and earth	Y

C) Condition Monitoring (Condition based Maintenance)

Sr.No.	Details	Frequency
1	Checking of leakage current (Third harmonic resistive current)	Y
2	Measurement of capacitance & Tan δ of each stack	SOS
3	Measurement of IR of each stack	SOS

7. WAVE TRAPS

A) Service Inspection Schedule


Sr.No.	Details	Frequency
1	Check for mechanical integrity of the main coil	Y

B) Maintenance Schedule

Sr.No.	Details	Frequency
1	Tightness and Cleaning of wave trap	Y
2	General inspection / cleaning of tuning unit	Y
3	Cleaning of post insulators (if provided)	Y
4	Repair of bird guard	SOS

C) Condition Monitoring (Condition based Maintenance)

Sr.No.	Details	Frequency
1	Thermovision scanning of joints	Y
2	HF characteristics of line trap	Y
3	Measurement of blocking impedance and blocking	2Y

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	resistance	
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M- Monthly, QY-quarterly, Y-yearly, 2Y-once in 2 years, 3Y-once in three years, 4Y- once in 4 years, SOS-as and when required.

3) CONCLUSION

The fundamental goal of inspection, maintenance and condition monitoring of substation is to preserve the function or operation of a system. Specifically, the function that has to be preserved for electric substations is the delivery of safe, reliable electric power to customers

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